Influence of Sedimentary and Seagrass Microbial Communities on Shallow-Water Benthic Optical Properties

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LONG-TERM GOALS

An overall goal of the CoBOP program is to produce a working radiative-transfer model for selected sub-littoral environments. From a microbiological context, it is important to investigate the entire community of microorganisms associated with the benthic environments of focus, i.e., sediments and seagrass. Light must pass through a "microbial gateway", both before it reaches the sediment or seagrass and prior to its return to the water column. To understand time-and-space variations in optical parameters, we must understand the microbial milieu in which they exist.

OBJECTIVES

Determine the interannual variation in the biomass and composition of sedimentary microorganisms at field sites nearby Lee Stocking Island, Bahamas, and in Monterey Bay, California.

Similarly, determine the biomass, composition, and temporal variation of microorganisms epiphytic on seagrass blades at Lee Stocking Island (turtle grass, *Thalassia testudinum*) and in Monterey Bay (eel grass, *Zostera marina*).

Assess how the microbial community affects the flux of photons to and from the sediments and seagrass blades and how temporal changes in the microbiological community influence temporal changes in benthic optical characteristics.

APPROACH

Our approach is to combine extensive field sampling of sediments and seagrasses with biochemical determination (membrane lipids--Dobbs) and microscopic examination (light and scanning electron microscopy--Drake) of their microbiological constituents. These fundamental observations then serve as the basis for comparison with the sediments' and seagrasses' optical properties.

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14. ABSTRACT
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WORK COMPLETED

Between September 1997 and June 2000, we participated in five expeditions at Lee Stocking Island (LSI) in the Bahamas as well as six sampling trips to Monterey Bay, California; in all cases a suite of samples was collected for analysis of microorganisms associated with sediments or seagrass. Fiscal year 2001 served as the "out-year" of this grant and was dedicated to sample work-up, data analysis, and preparation of manuscripts. Here we summarize our progress on several research fronts. Highlights of our results are presented in the following section.

1) In October, we will submit a manuscript, authored by Drake, Dobbs, and Zimmerman, and entitled "Effects of epiphyte load on optical properties and photosynthetic potential of the seagrasses *Thalassia testudinum* and *Zostera marina*". The manuscript will be submitted to the special optics issue of Limnology and Oceanography.

2) We have completed lipid analysis on more than 550 samples of surficial sediment and seagrass epiphytes collected from LSI and Monterey Bay. There are two types of lipid analyses we have performed. The first yields a microbial biomass value (Dobbs and Findlay, 1993) and the second, more involved analysis, yields a profile of the microbial community based on its membrane lipid, fatty-acid signatures (Findlay and Dobbs, 1993).

3) In the course of this research, we have developed our intriguing observation of large, refractive crystals in *Thalassia* from LSI. We have pursued this serendipitous discovery, and at the Estuarine Research Federation meeting this fall, we will present a poster by Dobbs, Drake, and Zimmerman entitled, "Crystalline inclusions in epidermal cells of turtlegrass, *Thalassia testudinum*: What is their significance?"

4) Finally, as required by Program Manager Steve Ackleson, we have and will continue to submit our data in a timely fashion. A summary of all data we collected throughout the CoBOP field program was submitted to Dr. Charlie Mazel on 1 February 2001. The synopsis, located on the CoBOP website (http://www.psicorp.com/lsi/dobbs_drake_data.htm), includes general descriptions of each data type, the analytical procedures used, data format, and data storage location.

RESULTS

1) Leaf epiphyte loads were determined quantitatively, by removing epiphytes and measuring their lipid biomass, and qualitatively, using light microscopy to characterize the colonizing organisms. Light absorption and backscattering of the intact epiphyte layer were determined spectrophotometrically. Epiphyte biomass increased non-linearly with leaf age. *T. testudinum* epiphytes from LSI absorbed a maximum of 32% of incident light in peak chlorophyll absorption bands and 30% of total PAR. Higher epiphyte loads on *Z. marina* from Monterey Bay absorbed 59% of incident light in peak chlorophyll absorption bands and 48% of total PAR. Data were incorporated into a model that predicts the biomass-dependent light attenuation of the epiphyte community (Fig. 1). These results are useful for determining quantitative and qualitative impacts of epiphyte loading on the photosynthetic performance of seagrass leaves. (Drake et al., 1999a,b; Drake et al. 2001; Drake et al., in preparation for Limnology and Oceanography)

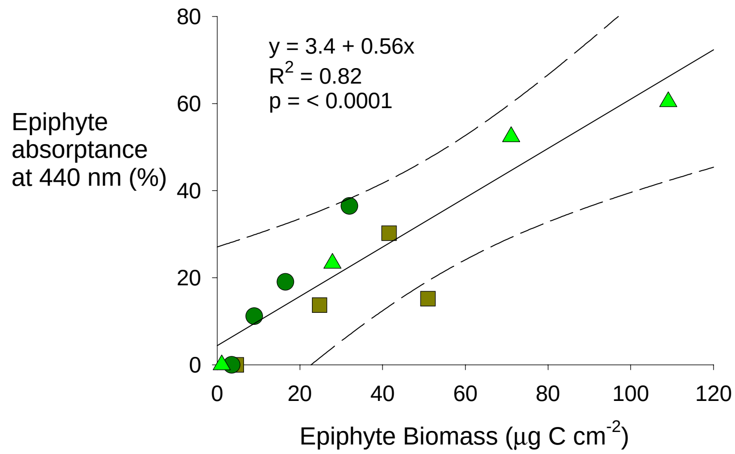

Figure 1. Epiphyte absorptance vs. epiphyte biomass at 440 nm. Data represent measurements from seagrass leaves from each of three sites: circles = Channel Marker, LSI, Bahamas; squares = Rainbow South, LSI, Bahamas; triangles = Elkhorn Slough, Monterey Bay, California. Dashed lines represent 95% confidence intervals (Drake et al., in prep).

2) In an example of lipid-based microbial biomass shown here (Fig. 2), there was more than a 10-fold difference in sedimentary biomass among sediment archetypes collected at LSI during the 2000 campaign. We are now assembling the very large data set of microbial biomass and fatty-acid profiles we generated for LSI and Monterey Bay sediments. Our intent is to assess interannual variations in those sedimentary microbial communities. (Dobbs and Drake, in preparation)

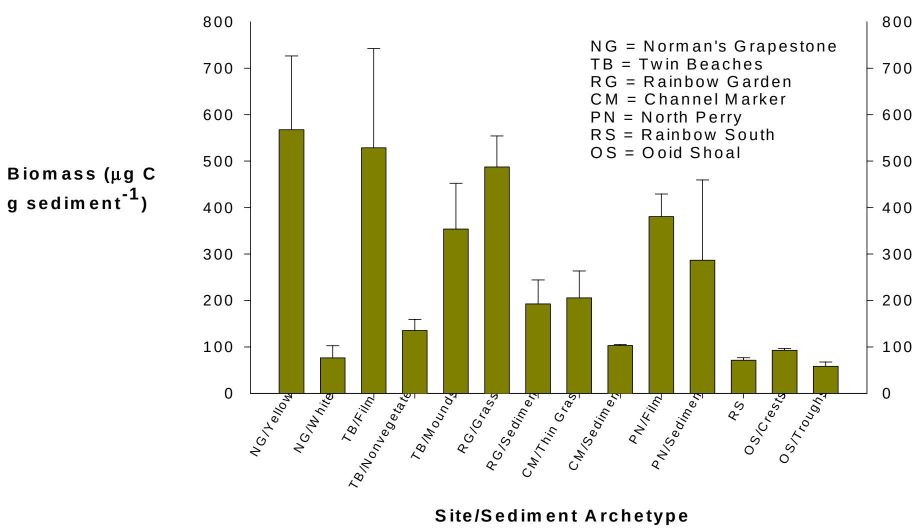

Figure 2. Microbial biomass in surficial sediments nearby Lee Stocking Island, Bahamas. Samples collected in May 2000; error bars represent one standard deviation.

3) Intracellular crystals have been reported from a variety of vascular plants and macroalgae, but their biological significance remains enigmatic. In the course of this research, we have found large, refractive, rhomboidal crystals (Fig. 3) in *Thalassia testudinum* from the Bahamas (Lee Stocking Island), Florida (Key Largo and Key West), and Texas (Laguna Madre). At all four collection sites, crystals were present in leaves of all ages and in most, but not all, epidermal cells. The presence of a surrounding membrane has not been detected with light microscopy, but absolute determination will require electron microscopy. Epidermal cells generally contained a single, monolithic, rhomboidal crystal, but cells from Key West frequently contained two or more conjoined crystals. Crystals were stable in acid (pH 2.5) but were partially dissolved in base (pH 14). The size, morphology, and distribution of *Thalassia* crystals are remarkably similar to proteinaceous crystals described in red and brown algae, but are very different from calcium salt crystals found in idioblasts of terrestrial plants. We are further investigating these unusual and previously unrecorded structures. (Dobbs, Drake, and Zimmerman, 2001)

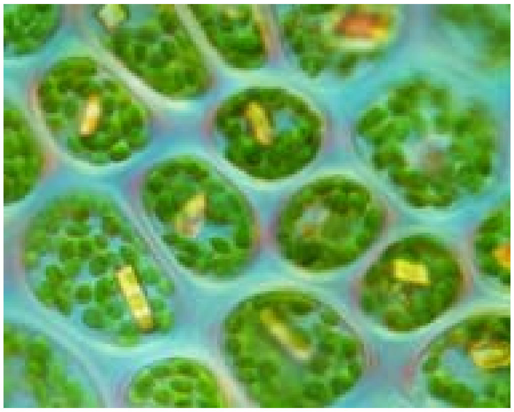

Figure 3. Intracellular crystals within epidermal cells of turtle grass, Thalassia testudinum, collected nearby Lee Stocking Island, Bahamas. Original magnification = 400x.

IMPACT/APPLICATIONS

Any surface in an aquatic environment is covered to some degree with a microbial menagerie that may affect the quantity and spectral quality of light for at least several different reasons. Thus, before incoming light reaches the sediment or seagrass blades and before any light returns to the water column, it must pass through a microbial "gateway" that may affect its quantity and quality. The present incorporation of microbiology into environmental optics research sets the stage for future investigations, in which not only closure is a goal, but a more precise understanding of the interactions between light and organisms.

TRANSITIONS

See collaborations with other CoBOP researchers listed in "Related Projects".

RELATED PROJECTS

In the past year, we continued our collaboration with CoBOP researcher Dr. Dick Zimmerman, with whom we are conducting a biochemical, microscopic, and optical characterization of epiphytes on the leaves of sea grasses found at LSI and in Monterey Bay. The epiphyte data will supplement the photophysiological information obtained by Zimmerman in his development of a canopy production model for sea grasses.

We have initiated collaboration with Dr. Pamela Reid (University of Miami) to investigate the interplay of TSRB data with our microbial data. Our intent is to identify relationships between bottom reflectance and the sedimentary microbial community.

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